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25 May 1961

MEMORANDUM FOR: Chief, EB/Senior Planning Officer

ATTENTION : [redacted] 25X1

SUBJECT : Signal Flare Study

1. Attached is a copy of the final report on the signal flare study which [redacted] spoke to you about recently. This report is for your use and retention and covers the program of study of commercially available thirty-minute burning time railroad fusees. This study covers such subjects as availability, reliability, surveillance, visibility, and shielding of the flame for both red and yellow railroad fusees. 25X1

2. If you would like any further information regarding this study or to discuss other work on these items, please contact [redacted] 25X1
[redacted] 25X1

[redacted] 25X1

Chief
TSD/Engineering Branch

Attachment:
As Stated

EB/P/TSD/EB/HC

Distribution:
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EB:182 - Incendiary, General

FINAL REPORT
ON THE
SIGNAL FLARE STUDY
RD 45, TASK ORDER LL

14 April 1961

ABSTRACT

A study was undertaken of commercially available 30 minute burning time railroad fusees, in both red and yellow. This study comprised availability, reliability, surveillance, visibility, and shielding of the flame.

The results were as follows: Several manufacturers exist for these flares. None of the flares are fully reliable if the Bureau of Explosives Specifications for certain water-resistance tests are included. However, some generally serviceable brands were found.

INTRODUCTION

Prior to receipt of the contract on 23 May 1960, a form letter was sent to twelve companies who were supposedly in the railroad fusee business, according to the Thomas Register. From the replies received, it appeared that only four companies were manufacturers, all of whom produced the red burning 30 minute flares; two of them also had the yellow burning 30 minute flare available. One (Standard) mentioned a 45 minute red fusee besides their 10, 20, and 30 minute items.

Orders for one half gross (72 items) of each type were placed with the manufacturers. In one case, a replacement order was received after our complaint about the inferiority of the merchandise.

TESTS PERFORMED

The flares were to be tested for (1) ease of ignition; (2) burning time; (3) ability to burn after five days at -20°F;

(4) ability to burn after five days at 110°F; (5) ability to withstand a simulated rain and windstorm; (6) ability to be burned after 10 minutes submersion under water and also for burning; (7) visibility after dark both from the ground and from the air for color brightness and ability to be seen at a distance.

The flares used for these tests were from the following companies:

I. Standard Railway Fusee Corp., (Red) Boonton, N. J.

II. Olin Mathieson Chemical Corp., (Red) East Alton, Ill.
(Plant: Peru, Ind.)

III. Bristol Flare Corp., (Red) Philadelphia 3, Pa.
(Plant: Bristol, Pa.)

IV. Bristol Flare Corp., (Yellow) " " "

V. International Flare Signal Division (Red) Kilgore, Inc.
Westerville, Ohio

VI. International Flare Signal Division (Yellow) " "

The first test performed was to burn twenty flares of each brand and each color noting weight of the flares, ambient temperature, wind velocity, ease of ignition, chimneying effect, approximate flame length, time to full flame, total burning time, and other pertinent facts.

During this test, the Bristol flares (both red and yellow) were the only ones to have 100% successful burns from ignition. The Bristol red had a good average burning time of 32.26 minutes, while the Bristol yellow's average burning time was only 18.5 minutes.

The Bristol flares were the best made of these flares, while the originally furnished Kilgore flares used in these tests were the worst and appeared to be in a state of decay. The complete results of this test are found in Table I.

The second test was to burn ten flares of each brand and each color immediately after they had been kept at 110°F for five days, noting all the same information as in the first test. All the flares except the Kilgore red had 100% successful burns. All the red flares had an average burning time of about 30 minutes, while the yellow flares fell considerably below this time. The complete results are found in Table II.

TABLE I

This test was made under mild summer conditions with temperature from 70° - 90°F and wind from calm to 17 MPH. The flame length of all the red flares was approx. 2½" - 3" and the yellow flame length was from 3" - 4".

Name & Remarks	Weight	Ease of Ignition	Chimneying Effect	Time to Full Flame	BT in Min.
I Standard Railway Fusee Corp. (Red) Gen. Appearance: Heavy wax coated with well sealed wood plug in bottom, Spike 1½" long, Length 17", Diameter 1" Gen. Performance: Fair, 3 out of 20 flares failed to burn to completion from ignition.	312 gm to 322 gm	Good	Very little chimneying	1½ to 2 min	Av. 31.76 Min. 30 Max. 33
II Olin Mathieson Chemical Corp. (Red) Gen. Appearance: Light wax coating with well crimped wood plug in bottom, Spike 1-3/8" long, Length 18-1/8", Dia. 15/16". Gen. Performance: Over 1/2 of these flares had a very weak flame at start, 3 out of 20 failed to burn to completion from ignition.	343 gm to 361 gm	Most of these difficult to ignite	Some chimneying on 5 Flares	1½ to 2 min.	Av. 36.29 Min. 34 Max. 39
III Bristol Flare Corp. (Red) Gen. Appearance: Heavy wax coating well sealed wood plug, Spike 1¼" long,	321 gm to 338 gm	Fair	Considerable chimneying on ½ these flares	1¼ to 2 min. Most under 2 min.	Av. 32.26 Min. 28 Max. 34
IV Bristol Flare Corp. (Yellow) Gen. Appearance: Heavy wax coating with well sealed wood plug, Spike 1¼" long, Length 18¼", Diamater 1". Gen. Performance: Very good, rapid burning, 100% successful burns.	341 gm to 363 gm	Very good	Little or no chimneying	1 to 1½ min.	Av. 18.5 Min. 17 Max. 20

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TABLE I (Continued)

This test was made under mild summer conditions with temperature from 70° - 90°F and wind from calm to 17 MPH. The flame length of all the red flares was approx. 2½" - 3" and the yellow flame length was from 3" - 4".

Name & Remarks	Weight	Ease of Ignition	Chimneying Effect	Time to Full Flame	BT in Min.
V International Flare Signal Div. (Kilgore) (Red) Gen. Appearance: No apparent wax coating, some bent or broke in middle, plastic plug loose in bottom, Spike 1-3/8" long, Length 17-3/4", Dia. 1". Gen. Performance: Fair, one of these failed to burn, most of the flares were in a state of decay.	333 gm to 359 gm	Fair	Considerable chimneying on all flares	1½ to 2 min.	Av. 34.95 Min. 32 Max. 37
VI International Flare Signal Div. (Kilgore) (Yellow) Gen. Appearance: No apparent wax coating, some bent or broke in the middle, Spike 1-3/8" long, Length 17-3/4", Diameter 1". Gen. Performance: Very poor, 9 out of 20 failed to burn to completion, some went out when one half burned.	352 gm to 367 gm	Good	Considerable chimneying on most of these flares	Ranged from 1 to 3½ min.	Av. 30.54 Min. 26 Max. 38

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TABLE II

This test was made under mild summer conditions with temperature from 78° - 96°F and wind from calm to 18 MPH.

	Name & Remarks	Ease of Ignition	Chimneying Effect	Time to Full Flame	BT in Min.
I	Standard Railway Fusee Corp. (Red) Gen. Performance: Very good	Very good	Only 1 had mild chimneying	1¼ to 1½ min.	Av. 29.9 Min. 29 Max. 31
II	Olin Mathieson Chemical Corp. (Red) Gen. Performance: Very good.	Only 2 of these flares hard to ignite.	Only 1 had mild chimneying	1¼ to 2 min.	Av. 32.3 Min. 30 Max. 33
III	Bristol Flare Corp. (Red) Gen. Performance: Good.	1/2 of these difficult to ignite.	All but 1 had some chimneying.	1¼ to 2 min.	Av. 30.7 Min. 29 Max. 32
IV	Bristol Flare Corp. (Yellow) Gen. Performance: Very good, short time to full flame.	Very good	No chimneying noticed.	1 to 1½ min.	Av. 18.7 Min. 18 Max. 19
V	International Flare Signal Div. (Kilgore) (Red) Gen. Performance: Poor, Matchhead or base plug loose on all of these.	Good	Too much chimneying.	1 to 1½ min.	Av. 30.22 Min. 21 Max. 33
VI	International Flare Signal Div. (Kilgore) (Yellow)	Good	Too much chimneying	1 to 1½ min.	Av. 26.2 Min. 20 Max. 28

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The third test was to burn ten flares of each brand and each color immediately after they had been kept at -20°F for five days. During this test, the Olin Mathieson, the Bristol red and the Bristol yellow flares had 100% successful burns while the Kilgore yellow had 100% failure to burn and the Standard red flare had only 10% successful burns. Burning time in these tests was longer than at ambient temperature. The complete results of this test are found in Table III.

Since the Kilgore red and yellow flares were in such poor condition upon arrival, it was decided to ask for flares from a more recent production. Upon the arrival of the new lot, they were tested in the same manner as the previous flares. A 100% successful burning was found on all of these tests, but many of the exterior defects that were noted on the first shipment from Kilgore were noted on these also. The following are the complete results of these tests (Table IV).

TABLE III

This test was done at temperature of 78° - 90°F and wind from calm to 10 MPH

	Name & Remarks	Ease of Ignition	Chimney-ing Ef-fect	Time to Full Flame	BT in Min.
I	Standard Railway Fusee Corp. (Red) Gen. Performance: Very poor, only 1 flare burned to completion.	Good	Mild chimney-ing on 4	N/A	N/A
II	Olin Mathieson Chemical Corp. (Red) Gen. Performance: Fair, 1 would not light with striker	1/2 of these were hard to ignite	Some chimney-ing on all but 2 of these	2 to 3 min.	Av. 37.1 Min. 36 Max. 38
III	Bristol Flare Corp. (Red) Gen. Performance: Good	1/2 of these were hard to ignite	All had some chimneying.	1 to 1-3/4 min.	Av. 33.1 Min. 32 Max. 35
IV	Bristol Flare Corp. (Yellow)	Good	Little or no chimney-ing	1 to 1-3/4 min.	Av. 19.1 Min. 17 Max. 20
V	International Flare Signal Div. (Kilgore) (Red) Gen. Performance: Fair, plug loose on 9 of these flares	2 were hard to ignite	Too much chimneying on all of these	1½ to 1-3/4 min.	Av. 35.1 Min. 34 Max. 38
VI	International Flare Signal Div. (Kilgore) (Yellow) Gen. Performance: Very, very poor, none of these continued to burn from ignition.	N/A	N/A	N/A	N/A

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TABLE IV

All of these tests were made during early fall weather with temperature from 48° - 100°F with wind from calm to 10 MPH.

No., Name & Remarks	Ease of Ignition	Chimneying Effect	Time to Full Flame	BT in Min.
V (20) International Flare Signal Div. (Kilgore) (Red) (New Production) Gen. Appearance: Better than the first lot but still some have loose base plugs and cracked matchheads, average 20 gm heavier than first lot. Gen. Performance: Good, 100% successful burns	Very good	Too much chimneying on all	1 - 1½ min.	Av. 34.1 Min. 33 Max. 35
VI (20) International Flare Signal Div. (Kilgore) (Yellow) (New Production) Gen. Appearance: Good, no noticeable defects. Gen. Performance: Good, 100% successful burns.	Very good	Too much chimneying on all	1 to 1-3/4 min.	Av. 28.15 Min. 27 Max. 30
V (10) International Flare Signal Div. (Kilgore) (Red) Tested after 110°F for 5 days. Gen. Performance: Good, 100% successful burns.	Very good	Too much chimneying on all	1 to 2½ min.	Av. 32.2 Min. 32 Max. 33
VI (10) International Flare Signal Div. (Kilgore) (Yellow) Tested after 110°F for 5 days. Gen. Performance: Good, 100% successful burns.	Very good	Too much chimneying on all	1 to 1¼ min.	Av. 26.4 Min. 26 Max. 27
V (10) International Flare Signal Div. (Kilgore) (Red) Tested after -20°F for 5 days Gen. Performance: Fair, base plug loose on 4 and matchhead cracked on 2. One almost went out after burning 1/2 way.	Very good	Too much chimneying on all	1 to 1½ min.	Av. 37.2 Min. 36 Max. 38
VI (10) International Flare Signal Div. (Kilgore) (Yellow) Tested after -20°F for 5 days Gen. Performance; Good, burns 100% successful but striker loose in cap on one and base plug loose on another.	Very good	Too much chimneying on all	1 to 1¼ min.	Av. 30 Min. 29 Max. 31

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Unsuccessful tests were made to burn flares which had been submerged in water for ten minutes. This was done in accordance with one of the tests as specified in the Bureau of Explosives Specifications for red railroad fusees. The only one to ever burn during this test was one Bristol yellow flare.

Another test was made to see if the flares would burn under water for two minutes in accordance with one of the tests as specified in the Bureau of Explosives Specification for red railroad fusees. None of the flares burned under water for as long as 15 seconds.

A simulated rain storm test was performed at a wind velocity of 15 m.p.h. The Standard flare went out in thirty minutes and 1/3 of the flare remained unburned. The Olin flare burned weakly with excessive chimneying, however, it did burn to completion in 42 minutes. The Bristol red flare went out in twenty minutes with approximately 1/2 remaining unburned, but the Bristol yellow flare burned to completion in twenty minutes. Two Kilgore red flares went out within two minutes and one Kilgore yellow flare went out in one minute. A second Kilgore yellow flare had excessive chimneying, but burned to completion.

Night tests were conducted in the Project Officer's presence to determine the brightness and color of the flares, both from ground and aerial observations. In addition, it was attempted to make the light from the flares less conspicuous to a person noticing it on the ground.

The flares were burned in three locations (on top of ground, in pits, and in pits lined with aluminum foil). Four stations

were set up for each of four different manufacturers' red flares. Both red and yellow flares were burned, but in separate experiments. The following ground observations were made:

TABLE V

I. Ground Observations

		On Top of Ground Appearance Rating	In Pits	In Pits Lined With Foil
A.	Standard Red	1st place rating		A little more conspicuous than flares in unlined pits
B.	Olin Mathieson Red	Poor	All glowed vaguely	
C.	Bristol Red	2nd place		
D.	Kilgore Red	3rd place		
AA.	Bristol Yellow	Very poor	Incon-spicuous	A shade less conspicuous than the red
BB.	Kilgore Yellow			

Note: Any objects within close proximity to the pits such as weeds, rocks, and posts increased visibility, because light was reflected from these objects.

The following are the aerial observations of the same test. These observations were made during passes in a heliocopter at an altitude of approximately 750 ft. and a forward speed of approximately 85 m.p.h.

TABLE VI

II. Aerial Observations

		On Top of Ground	In Pits	In Pits Lined With Foil
A.	Standard Red	Very visible from a good distance	Poor visibility until directly overhead on all red flares with A & D the best	Fair
B.	Olin Mathieson Red	Poor		Good
C.	Bristol Red	Very visible from a good distance		Good
D.	Kilgore Red	Fair		Poor
AA.	Bristol Yellow	Less distinguishable from distance than the red	Not visible until directly overhead	Poor
BB.	Kilgore Yellow			Good

In general, it was noted that the red flares were more distinguishable than the yellow.

ADDITIONAL ITEMS

After the completion of the railroad flares, it was decided to obtain some marine flares and test them. We then obtained six signal (Distress Day & Night) Mark 13 Mod 0 Flares from Aerial Products, Inc., Merric, N. Y., and tested them. These flares burned much brighter and with a much longer flame, but they only burned from 20 - 30 seconds. Complete results of the test are found in Tables VII and VIII.

The flares were metal contained with pull igniters on either end. They were 5-1/8" long, 1-5/8" in diameter, and weighed 203 gm. One end was for night flare which burned with a very bright flame for about 7" to 10" in length and which had a very bright red color. The other end was a day signal which burned with a very bright yellow smoke.

These flares are a great deal brighter than any of the railway flares previously tested, but the pull igniters are much too difficult to actuate and are not dependable in igniting the flares.

TABLE VII

These night flares had a very rapid start and were to maximum flame in 5 to 7 seconds.

Night Flare No.	Length of Flame	Burning Time	Remarks
1	7" - 10"	25 sec	Good
2	7" - 10"	23 sec	Good
3	N/A	N/A	Pull igniter failed to ignite the flare
4	7" - 10"	20 sec	Good
5	N/A	N/A	Pull igniter failed to ignite the flare
6	7" - 10"	20 sec	

TABLE VIII

The day flares gave out a very dense, very bright orange smoke. It took from 10 to 15 seconds to maximum smoke.

Day Flare No.	Burning Time	Remarks
1	33 sec	Good
2	32 sec	Good
3	33 sec	Good
4	N/A	Flare ignited but immediately went out.
5	N/A	Pull igniter failed to ignite flare
6	33 sec	Good

Temperature at time of these tests was 35°F and the wind was 12 MPH.

SUMMARY

Commercial colored flares of the railroad fusee type are serviceable for the intended purpose if no better items are available, and if the conditions of use are not too severe. As cheap commercial items, the storage life of this type of flare is limited. It is doubtful that hermetic sealing of such flares would be the answer to the storage problem. However, fresh production, carefully tested and well packaged, perhaps in presence of bags of desiccant, would improve reliability of the items. Actually, for rugged field use, the items should be made better and should conform to all Bureau of Explosive requirements.

Another disadvantage is that the 30 minute flares are actually enlarged standard fusees and are top-heavy because the spike is too short for length of the flare.

Of the tested samples, the red flares appear preferable to the yellow ones as far as visibility from the air is concerned. Conversely, the yellow flare is less conspicuous to a casual ground observer.